The Summer Undergraduate Research Fellowship (SURF) Symposium
2 August 2018
Purdue University, West Lafayette, Indiana, USA

Design of selectively compliant morphing wind turbine blade section using bistable laminate for passive load alleviation

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ABSTRACT

The design of passively controlled compliant morphing structures for large scale wind turbine blades has been of interest due to the inherent advantages of lower mass and reduced complexity over their active counterparts. Previous studies have indicated that embedding a locally bi-stable element within the turbine blade section successfully allows for achieving passive load alleviation. The embedded bi-stable member switches from one stable state to another at a critical aerodynamic load. This local structural change results in a global shift in the aeroelastic response of the blade section. Building on these preliminary results, this research investigates a two-dimensional wind turbine morphing airfoil as a lumped aeroelastic model with three degrees of freedom. An aeroelastic analysis is performed with plunge, pitch and flap deflection degrees of freedom while considering the trailing edge flap as a bistable torsional spring. The nonlinearity in flap torsional spring is designed to qualitatively capture the behavior of a bistable element embedded within the trailing edge of morphing blade section. The results presented demonstrate alleviation of the aerodynamic load acting on the blade section by shifting between the two stable states of the bistable spring. Based on this study, a morphing mechanism can be developed for a full-scale wind turbine blade that counteracts cyclic loads by cambering a trailing edge flap. This design approach has the potential to reduce cyclic blade fatigue on horizontal axis wind turbines.

KEYWORD

Wind turbine, passive load alleviation, bistability, aeroelasticity, selective compliance